RE-ENGAGING ADOLESCENT STUDENTS IN SCIENCE: AN EXPERIENCED TEACHERS' CLASSROOM

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ABSTRACT

Adolescents are both aware of and have the impetuous to exploit aspects of Science, Technology, Engineering and Mathematics (STEM) within their personal lives. Whether they are surfing, cycling, skateboarding or shopping, STEM concepts impact their lives. However science, mathematics, engineering and technology are still treated in the classroom as separate fragmented entities in the educational environment where most classroom talk is seemingly incomprehensible to the adolescent senses. The aim of this study was to examine the experiences of young adolescents with the aim of transforming school learning at least of science into meaningful experiences that connected with their lives using a self-study approach. Over a 12-month period, the researcher, an experienced secondary-science teacher, designed, implemented and documented a range of pedagogical practices with his Year-7 secondary science class. Data for this case study included video recordings, journals, interviews and surveys of students. By setting an environment empathetic to adolescent needs and understandings, students were able to actively explore phenomena collaboratively through developmentally appropriate experiences. Providing a more contextually relevant environment fostered meta-cognitive practices, encouraged new learning through open dialogue, multi-modal representations and assessments that contributed to building upon, re-affirming, or challenging both the students' prior learning and the teacher’s pedagogical content knowledge. A significant outcome of this study was the transformative experiences of an insider, the teacher as researcher, whose reflections provided an authentic model for reforming pedagogy in STEM classes.

Keywords: *middle years, science teaching, PCK, classroom learning environment, teacher research, student engagement, science content self-study*

INTRODUCTION

Internationally there has been accumulating evidence that students are being turned off science and related areas of technology, engineering and mathematics (STEM). For instance, the OECD has presented data that shows declines in the percentages of students studying science, technology, engineering and mathematics (STEM) and recommended that governments take action to make science and technology studies more attractive to students (OECD, 2006). Other studies reinforce the perception that contemporary youth are not interested in STEM-related careers either in Australia (Ainley, Kos, & Nicholas, 2008; Barrington, 2006;

Dobson & Calderon 1999; Federation of Australian Scientific and Technological Societies [FASTS], 2002; Forgasz, 2006; Harris, Jensz, & Baldwin, 2005) or internationally (OECD, 2010; Reiss, 2007).

Given this context, the question arises as to what can be done to identify causes and to reverse the trend. The middle years of schooling appears to be a critical phase in the development of students' interest and dispositions towards a career. The issues around the engagement of young adolescents in schooling are complex and reasons why they might reject science and related disciplines are equally complex. Many explanations have been provided including that middle years classrooms are overly reliant on transmissive pedagogy and decontextualised content (Goodrum, Hackling & Rennie, 2001; Hanrahan, 2003; Lemke, 1990; Shamos, 1996; Symington & Tytler, 2003; Tytler, 2007) and lack an appropriate emotional climate (e.g., Ainley & Ainley, 2010).

The self-study reported here is a self-reflection of a teacher/researcher exploring his practice by challenging his existing approaches to teaching of science in the middle years of schooling. Warren, Author 1, an experienced teacher of 37 years, was becoming more aware of declining interest among his students in his science classes. Therefore, he wanted to examine the problem in a pragmatic way by reflecting on his teaching and to attempt to reverse the growing disinterest in his science classes and those of his colleagues. Initially during an exchange teaching program in North America, he was introduced to, and influenced by the middle school paradigm and the concept of scientific literacy as a rationale for teaching science. In particular the middle school paradigm offered specific pedagogical strategies and a theoretical framework that could provide opportunities to reform practice rather than perpetuate a classroom environment that would exacerbate risk for student engagement. The construct of scientific literacy appeared to provide some sense of purpose for students to aim at and see as of value for becoming active citizens. Thus, a science unit was designed to challenge the deficit view of adolescence (Prosser, 2006) by arguing that the adolescent students are more responsive toward learning if given an appropriate learning environment and meaningful goals which connect their learning with life beyond the fences of the school yard. The learning environment was considered to be the organisational structure of the classroom, the resources made available, the activities presented and the style of assessment of student understandings. In the broadest terms scientific literacy was conceptualised as those abilities to use scientific knowledge and skills to understand the role of science in contemporary society. In this study, Author 2 assumed the role of critical friend, advisor and catalyst to bridge theory and practice.

BACKGROUND

Science teaching is about drawing out different points of view by encouraging constructive argumentation and evaluating scientific information, supporting students to critique the way it is presented and manipulated in society all within mutually respectful environment. McCombs (2001) addressed the problem of student and teacher alienation by describing Learner-Centred Principles that could help create a respectful relationship between students and their teachers fostering a positive climate for learning. These Learner-Centred Psychological Principles are outlined in Table1.

Table 1: *Theoretical Framework to Inform Pedagogical Practice*

Learner-Centred Principles (LCP)	Key proponents (KP)
a) Cognitive and Meta-cognitive Factors	Meta-Cognitive Theory (McGuinness, 2005; Kuhn & Dean, 2004)
b) Motivational and Affective Factors	Motivational Theory (Pintrich, 2003; Ryan & Patrick, 2001; Wentzel, 2003), Broaden and Build Theory (Fredrickson, 2001) and Engagement Theory (Fredricks, Blumenfield & Paris, 2004)
c) Developmental and Social Factors	Developmental Theory (Vygotsky, 1931), Situated Cognition and Cognitive Apprenticeship (Brown, Collins & Duguid, 1989; Schuh, 2004) and Communities of practice (Lave & Wenger, 1991).
d) Individual Differences Factors	Self-Determination Theory (Ryan & Deci, 2000)

These principles provided a way of focussing in on approaches to teaching that would foster learning. However, the context of middle schooling and the need to engage students in learning needed to be subsumed within these principles. Both middle schooling and scientific literacy were seen from a socio-cultural perspective linking theories of learning with the theories of educative practice (Table 1). These theories led to a trail that crossed many paths. All paths had to be considered from the perspective of the classroom as a dynamic environment.

Middle schooling is predicated on an assumption that learners are in dynamic state of becoming aware of themselves and others around them and seeking to find identity and confidence. Teachers' primary responsibility is therefore on supporting young adolescents to develop into autonomous, self assured contributors to society. Thus teaching begins with the interests and abilities of the learner. Learner-centred environments help students construct their knowledge and skills building on the understandings, beliefs, and cultural practices that they bring to the school (e.g., Alexander & Murphy, 1999; Donovan & Bransford, 2005). Instructional techniques that foster discussion, cooperative learning, and individualised inquiries are central to locating the individual learner at the centre of focus. Thus, from a middle schooling perspective the teaching and learning program was developed with an emphasis on a less compartmentalised approach than traditional science programs by having a more thematic and flexible design (Braggett, Morris & Day,1999), within a learner-centred framework. The teacher, Warren, influenced by a constructivist epistemology, wanted to convey a positive view of science as an active mechanism for learning.

Although there are multiple definitions of scientific literacy, the important features that informed this study included the need to provide students with opportunities to acquire conceptual understanding but also that the knowledge they were acquiring was of practical value to them now and in the future. Acknowledging the fragile interests of middle years students, Warren's immediate goal was to develop in adolescent students a core scientific literacy (Hill & Russell, 1999; Jablon, & Van Sickle, 2003; Kuhn & Dean, 2004; Tytler, 2007) based on student negotiated perceptions of their shared practical experiences of science and where possible linking scientific learning to local settings that may generate a sense of relevance to their lives (Holbrook & Rannikmae, 2009). The intended outcome was to pique their interest by establishing a sense of personal connectedness between the content and their lives.

The details of the content of the teaching program and how it capitalises on the Learner-Centred Principles are described in the methods section of this paper. The teaching formally reported on here was implemented over two school terms.

AIMS AND RESEARCH QUESTIONS

In this paper we report the dynamics of Warren's classroom interaction during one lesson. This was part of a purposeful and reflective intervention carried out over 12 months in his Year 7 classroom. The larger study attempted to address the question "What are the features of the classroom structure that promote a learner-centred intervention that emphasises cognitive engagement and growth?" This paper addresses the research sub question: what strategies can be adopted to make science content meaningful to adolescent learners? The relevant content included the core ideas of particle theory, water and living things with the *process* of science. Scientific ideas included factual information, the processes of science and the application of science. These ideas were strengthened by a variety of representational material that provided connected interactive experiences offering the students a way to act their way into thinking scientifically. The proposed instructional program (Table 2) highlighted the initial focus areas, particles of matter, water and life forms of the region. Although the proposed instructional program was written as a sequence in reality this did not occur. Students were given the opportunity to re-work scientific ideas in different contexts.

METHODS

A case study approach (Yin, 2002) was adopted to guide the design of this study. The study was undertaken in a regional coastal high school located in a mixed tourist and agricultural area. The socio-demographic of the community was on the Index of Community Socio-Educational Advantage at a value of 976, the average school value is 1000 (Barnes, 2010). The participants were 29 newly enrolled year-seven students who arrived from the various feeder primary schools both local and urban. The class was one of two parallel classes selected on high academic merit as judged by the feeder schools. The school offered seven Year 7 classes. Warren wished to challenge the orthodox approach to teaching science by initially dispensing with the traditional compartmentalised teaching starting with a overview of science an “Introduction to Science” and then moving on to specific topics. Instead, the students were immediately confronted by a more holistic approach to teaching conceptualised by Warren as an amalgam of scientific concepts infused with an abstract concept (particle theory) within the local context of water and living things.

Teaching Program

The teaching program was implemented over two terms of the school year, in all 20 weeks. During the first term the students had performed a series of set “hands on” activities relating to particle theory (Table 2). Given the proximity of the school to the ocean, Warren postulated that water could become an underlying phenomenon through which students could anchor their thoughts about particles of matter, water being a resource that offered many relatively easy and safe ways to exemplify states and properties of matter. Warren’s initial thoughts were to encourage the students to perform set practical exercises in a way that may be novel to them and thus may help precipitate the development of a core understanding of how materials behave when subjected to different physical conditions relating to properties of matter (Sherman, 2004). Activities selected by Warren were simple one-period exercises within the reductionist paradigm as opportunities to encourage students to collaboratively observe and describe simple scientific processes within self-allocated groups. Lessons within the reductionist paradigm were recognised by Warren as a compromise between the prescriptive syllabus which would dictate content of exams and a way of establishing a familiar routine working environment toward a future more autonomous classroom setting. Students were able to physically manipulate objects in the concrete domain before they were introduced to the more abstract concepts of science (Stuessy, 2001). Warren demonstrated activities to the students and then encouraged them in small groups to perform simple scientific investigations in order to become familiar with the scientific apparatus and to establish safety techniques within a social environment where students would be comfortable communicating with both fellow students and the teacher. The students collaboratively manipulated laboratory equipment, observed some sort of physical change and then after task completion class discussions of the results led to a simple diagram and conclusion, usually communicated by Warren.

Warren left the particle theory component to student groups to produce a PowerPoint presentation “States of Matter and their Properties” as an open-ended assignment (See Table 2 row 1). Warren, believed that the students were more adept at retrieving information (Spender, 2001) from electronic sources, and that adolescent students should be encouraged to display their competence (Jablon & Van Sickle, 2003) with this medium. The electronic medium provided a more flexible means of representing information and allowed for presentations to be less generic than text books or Warren’s explanation. Although the students retained a copy of the assignment it was not formally part of their book work.

By the second term Warren wished for the students to have more time exploring scientific phenomena associated with water as a means of developing an over-view of the properties of matter (Table 2). This became a series of extended activities more so than exercises with a more systems orientation in the expectation that the general principles that applied to particle theory could be eventually interpreted within the context of the student experiences in relation to the broader environment. The lessons were conceptualised by Warren as a fusion of scientific concepts integrating the topics of particles of matter within the local context of water “Water of the Region” and living things “Life forms of the Region” (Table 2). The local habitat provided a focus, linking the class community to the environment through the means of observation, measurement and manipulation of that habitat. By linking the class to the outside community via the local dune-care group it was postulated that this link could contribute toward each student’s interest and understanding of the principles, processes and practices of science, helping develop a scientific literacy.

Links were established between the conceptual framework relating to the four learner-centred principles (Table1) and the instructional program (Table 2). Group work incorporating projects and re-working of specific concepts in class were associated with *cognitive and meta-cognitive factors* (a). Novel activities to stimulate intrinsic interest related to *motivation and affective factors* (b). Initially students’ were given more opportunity to experience hands on group activities before introducing abstract concepts related to *developmental and social factors* (d) and open-ended activities and assessment work factored in, in consideration of *individual difference factors* (e).

Table 2: *The Planned Instructional Program*

Focus Areas		**Term/ Week**	**Scientific Concepts**	**Conceptualisation** (How the concepts are presented)	**Learner-centred strategy**
Investigations **Laboratory safety** **Use scientific equipment** **Make and record observations** **Draw conclusions based on information presented** **Manipulate and interpret data from graphs and tables.**	**Particles of Matter**	Term1 1-10	States of matter Properties of matter Particle theory Particles of matter sustain all life-forms	Make a model of the water-cycle in the laboratory Make a Cartesian diver Weigh balloons Make a simple thermometer Produce a slide show explaining states of matter and their properties	Concept mapping Learning teams Project-based learning
	Water of the Region	Term2 1-6	The forces that influence the hydrosphere. The properties of water. The states of water The distribution of water. Water is a finite asset. Water sustains life.	Read tide charts. Graph time taken and temperatures to boil salt water. Determine the salt content of creek water and water from beach rock pools. Determine the water content of pop corn. Audio-visual presentation	Learning teams Concept-mapping Project-based learning
	Life-forms of the Region	Term2 7-10	Characteristics of living things. Life-forms can be classified (living/non living) The five (5) Kingdoms of living things. Diversity of life-forms within specific niches.	Observe and record life-forms of beach rock pools and a creek. Microscopic examination of organisms. Grow sprouts at home Make a dichotomous key. Co-work with local dune-care group to identify, record, life-forms and re-generate plants on the dune.	Concept-mapping Learning teams Problem-based learning Project-based learning

DATA SOURCES

Design experiment methodology (Brown, 1992) was selected as a means of analysing the social dynamics of the classroom with the premise that learning is not done in isolation. Design experiments are conceived as a means of finding things out in the dynamic context of the classroom; by designing an environment that can be formally analysed, it is postulated that researchers may be more able to understand what is happening and why it happened, as a way of developing a model of the classroom environment that can be reported on to fellow educators. That is, taking what we know about learning and taking what we know about practice and putting them together (Kolodner, 1999). In order to analyse the dynamism of the classroom environment evidence was gleaned from both quantitative and qualitative sources in a partially mixed methods research approach dominated by qualitative data with the concurrent collection of quantitative data to corroborate interpretations (Leech & Onwuegbuzie, 2009).

Qualitative data were drawn from four sources (a) video recordings of all lessons, (b) interviews with selected students after each lesson, (c) student artefacts and work samples, and (d) journal reflections kept by the researcher. Lesson video tapes were transcribed and the dynamics of each lesson analysed using a quantitative observation tool – the Science Classroom Observational Protocol System (SCOPS). This tool was used to graphically document how the use of different forms of external representations (see later) can help augment students' internalisation of these representations toward construction of conceptual models of science (Stuessy, 2001). Interviews were transcribed and thematic analysis conducted to identify the salient features that the students experienced in each lesson. Selected student artefacts were interpreted within a science literacy framework based on the *content* found within the artefact; that of the three principles of scientific literacy: (a) Scientific knowledge, (b) Scientific process and (c) Scientific application.

Initially, Warren was looking for evidence of scientific knowledge including conceptual understandings related to cause and effect, related to vocabulary, and logical structure of the report. Scientific process was assessed by looking for the conventional methodological representations of data presentation and concluding remarks. Scientific application was judged by any reference to the concepts illustrated outside of the classroom environment. The artefacts presented were assumed to be the externalisation of student understandings as models, in this case student models were defined as the presentation plus the explanation (Merritt, Krajcik & Shwartz, 2008).

The teaching journal (sample entry shown in Table 3) was especially important as it was used to juxtapose the intended content and the actual context (Hoekstra, Brekelmans, Beijaard & Korthagen, 2009). In other words, the teacher's expectations of the lesson and what actually happened? The journal was written up each day after viewing the video record, scripting SCOPS and writing up the transcripts from lessons.

Table 3: *A Sample of the Teaching Journal*

Date	What was tried?	What actually happened?
27/04/05 Lesson 1 (third period)	Following a teacher demonstration the students performed an activity to observe the process of diffusion in liquids. Crystals were dropped down a straw in a beaker of water and the resultant diffusion of colour was observed.	The students were enthusiastic and involved and went on to experiment with different ways the crystals would behave in the water. The video camera was a little distracting to some boys, however after a brief encounter with the video were back to task (from video surveillance the students were enthusiastic about this simple experiment, maybe because they had time to actually direct the way they performed the experiment). A discussion ensued (teacher instigated) in order to determine what was happening. The teacher then placed oil of peppermint in the room to demonstrate diffusion of gases. The students wrote up the prac working backwards to define their own aim for the prac.

Further analysis consisted of examining the themes that emerged from individual sources to develop theoretical concepts. Processes similar to constant comparative analysis were adopted to seek corroborating evidence or contradicting evidence emerging across the multiple data sources. The Constructivist Learning Environment Survey (CLES) (Taylor, Dawson & Fraser, 1995) was conducted both at the beginning and end of term two to monitor changes in the learning environment. From a motivational perspective, Warren was looking for student behaviours associated with the different levels of engagement with the curriculum (Fredricks, Blumenfeld & Paris, 2004). The levels of engagement were considered by Warren to be hierarchical, starting with *emotional engagement*: considering work orientation, positive and negative reactions, student identity with the class, interest/boredom and willingness to undertake challenging task. *Behavioural engagement:* considering student participation, students on task, student questioning, completion of work and, enthusiasm, and *Cognitive engagement*: relating new knowledge to existing knowledge, exerting effort, requesting clarification, independent work styles and analysing understandings.

RESULTS
In the spirit of self-study, the results are presented in the first person reflecting the voice of Warren the teacher and first author of this paper. This approach aims to provide a readable and engaging story through which the themes central to teaching and the improvement of teaching are evident (e.g., Bullough & Pinnergar, 2001).

Instructional implementation

The teaching program evolved over 40 lessons. Described here is one lesson that was a precursor to an extended set of lessons focussed on life-forms of the region (Table 2). Within my curricular understanding of "life-forms" students had been subjected to an array of connected experiences associated with both the biotic and abiotic components of the environment. Lesson 25 was conducted in the classroom a period after the students the previous day had been involved in a sand dune re-vegetation exercise associated with the local community Dune Care organisation. SCOPS (Figure 1) graphically identified the sequence of the lesson (lesson 25) as a scaffold. The SCOPS graphical representation of classroom complexity identified four variables that reflected the dynamic nature of the classroom environment.

The first variable represented the sequencing of the lesson by identifying the number of individual segments that distinguish the lesson, defined by the % time on class. The second variable (red) depicted the level of student-centred activities related to participation and initiative (right side) compared to the teacher-centred practices of direction and student reception (left side). The third variable was related to the number of external representations within the lesson, yellow indicating symbolic representations of words and numbers including talk, green indicated pictorial representations and blue indicated representations of manipulating objects. The fourth variable related to levels of participation depicted by the number of boxes coloured in.

Figure 1 below depicted a lesson in which I initially demonstrated and explained *(modelled)* what was to be attempted. I attempted to engage the students in discourse toward clarification of any ambiguity associated with my explanation. I incorporated physical objects into the explanation, indicated by the blue square (see transcript below, lines 1-10). I then verbally helped the students *(coaching)* and then took a less supervisory role *(fading)*, whilst students engaged in manipulating physical objects (blue squares), discussing and arguing (yellow squares) the students' being attributed a degree of autonomy (red squares).Finally I helped the students through discussion to identify scientific principles associated with the activity *(articulation)*, I tried to align the two concepts that the students were familiar within the context of the activity related to particle theory (see transcript below, lines 11-26). This alignment was attempted by an amalgam of activities over three lessons, culminating in an assessment.

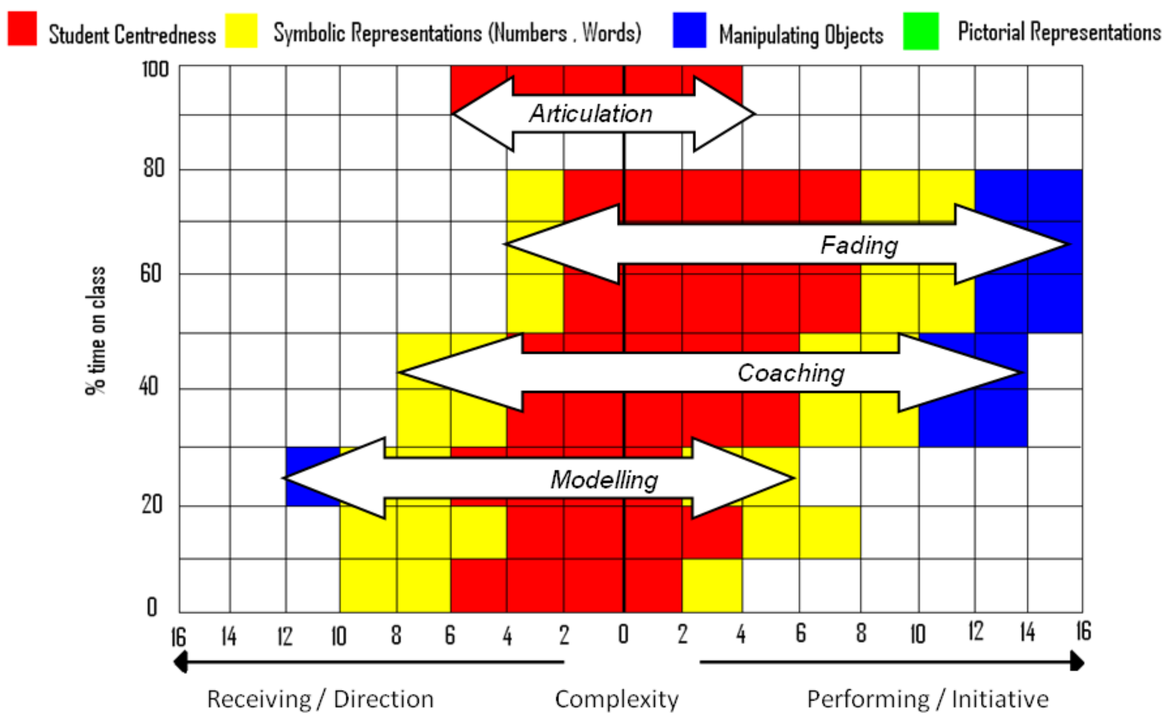


Figure1: *Scripting of classroom activities using SCOPS*

The following transcript captures an exchange between teacher (T) and students (S) during teacher explanation (modelling).

1. T-You're going to get some rock, [teacher holds up the rock with tongs] you're going to get pair of tongs, and you are going to put goggles on, sorry safety glasses. Over a Bunsen, not the safety flame but the other flame, you are going to heat the rock up, you listening [students talking about what they will do] have you got that so far? You're going to have a beaker of cold water.
2. Nigel [contributes] It's going to go shhhhh.
3. T-Its cold water, you are going to gently place the very hot rock into the water, [the teacher modelling the activity] you are not, Danny, Danny you ready!
4. Danny-[calls out] What!
5. T- We are not going to break any beakers!
6. Danny- I've only done it once!
7. T- [Teacher laughs] We are going to place it in the bottom of the beaker and then you are going to repeat that about ten times.
8. Ely [hand up] How long do you hold it in the flame for?
9. T- You'll find that out, say half a minute
10. T-OK, can we get that organised?

I (Warren) wished to encourage the students to clarify verbally how they would perform the activity, explicitly reminding the students of safety considerations (Lines 1-10).At the end of the lesson I considered it important that the students start to reflect explicitly by encouraging dialogue (*articulation*) related to what they had succeeded in doing and relating this to student prior knowledge (Lines11-26).

11. T OK, just briefly before we go. That was going back basically to the sand dunes. That was rock, called granite. Ely today what did you do you heated the granite and it?
12. Ely- Fell apart.
13. T- Fell apart right. So what happened first? [points to Richard]
14. Richard- We heating it!
15. T- OK, by heating it you expanded it and in the cold water it? [points to Oliver]
16. Oliver- Contracted.
17. T- Contracted fast, it expanded and contracted fast. What happened to the particles? [looks at Nigel]
18. Nigel- They fell off!
19. T- They fell off, they broke apart. OK, Amy that's the important part of the experiment, and you just missed it. [Amy not interested] Now what are soils made of particles, particles of what?
20. S-[contributing] Dirt and rock, water and rock, matter, minerals, rock!
21. T- Rock, so what have you started to make today?
22. S- [together] Soil [Boyd makes a statement inaudible to the whole class]
23. T- Aha Hah Boyd, say that again!
24. Boyd- It's caused by the sudden change from the heat from the bunsen to the cold water.
25. T- That's exactly right, that sudden change [teacher gestures with his hands held out] boom boom to boom boom [gesturing with hands pushed in] and somethings got to give!
26. Nigel- [tells the teacher] You have to change the water all the time because the water is getting hotter and hotter.
27. T Yeh, OK, everyone can go.

I was specifically looking for indicators of student engagement as a sequence from initial interest to scientific understanding. It was proposed that if students could develop some emotional engagement with the *content*, behavioural engagement may follow and precipitate cognitive engagement (Fredricks, Blumenfield & Paris, 2004). *Emotional engagement* was observed and recorded via the teaching journal, identifying that the students generally enjoyed the activity.

> The activity appeared to be enjoyable to all students observing the fragments of rock breaking off. This was, in a way, a *sensory experience* heating the rock until it glowed and then the noise as the rock was immersed in the water. The activity could also be considered a *risk taking activity* within the confines of a safe environment for these adolescents. (Teaching journal, 23/06/05)

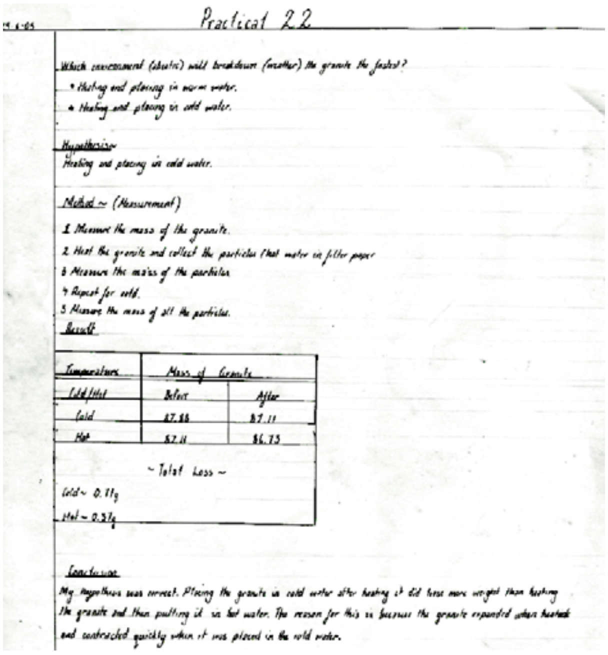
Behavioural engagement was also observed; all the students worked industriously and autonomously as I took a lesser supervisory role *(fading).* A student was prepared to contribute his observations telling me "you have to change the water all the time because the water is getting hotter and hotter" (Line 26). *Cognitive* *engagement* was evidenced by student responses to the teacher questions (Lines 20 and 22), and the student prepared to give an explanation to the class (Line 24).

The following day (lesson 26) some students were away at a swimming carnival. As the remaining students were still interested and enthusiastic about the last activity, I encouraged them to heat up more granite, and this time, at the students' request, they observed the broken rock fragments under microscopes. During the activity I noted some students were investigating with hot water and cold water and making inferences related to the rock fragments observed under the microscope. On the third day (lesson 27), with interest witnessed by the level of student participation I proposed to extend the activity challenging the students to discover which environment produced the most rock fragments and design an experiment to determine the same. Normally I would scaffold the activity on the board, with an aim, hypothesis, method, result table and conclusion. However I decided to remove the scaffold and request the students write up the activity in a conventional form including presenting their results and a conclusion as a means of assessing the development of a scientific understanding. The students then continued with the activity. Video records were by evidenced the teaching journal entry:

> They all [the students] seemed enthusiastic (even though this was the third day for some on the activity). This time a lot more measurements were taken and recorded. I'm very impressed at the student's ability to work cooperatively and stick to the activity in general. The activity flowed so I had a lot of time to interact with the students, lots of questions were asked. (Teaching journal, 27/06/05)

Outcomes

Outcomes data were drawn from student work samples, interviews and the Constructivist Learning Environment Survey (CLES). The teacher assessed student reports looking for evidence of a developing scientific literacy. Three student work samples follow Figures 3, 4 and 5.



19-6-05 Practical 22

Which environment (abiotic) will breakdown (weather) the granite the fastest?
• Heating and placing in warm water.
• Heating and placing in cold water.

Hypothesis
Heating and placing in cold water.

Method ~ (Measurement)
1 Measure the mass of the granite.
2 Heat the granite and collect the particles that water in filter paper
3 Measure the mass of the particles
4 Repeat for cold.
5 Measure the mass of all the particles.

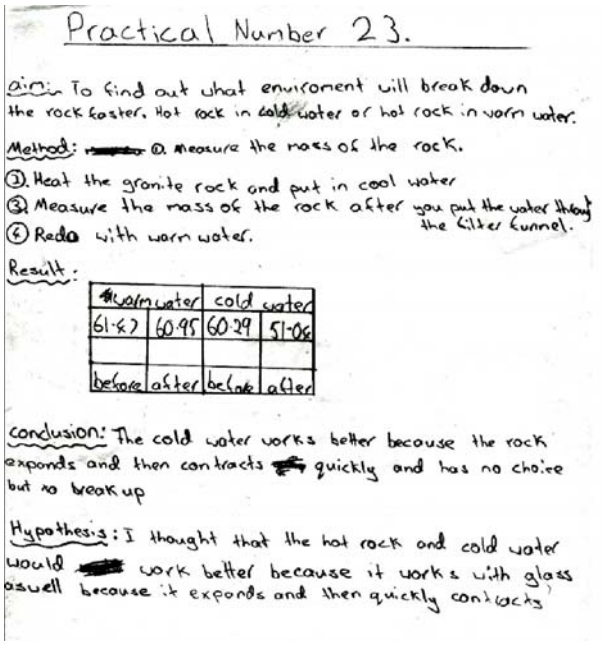
Result

Temperature	Mass of Granite	
Cold/Hot	Before	After
Cold	57.18	57.11
Hot	57.11	56.75

~ Total Loss ~
Cold ~ 0.11g
Hot ~ 0.37g

Conclusion
My hypothesis was correct. Placing the granite in cold water after heating it did lose more weight than heating the granite and then putting it in hot water. The reason for this is because the granite expanded when heated and contracted quickly when it was placed in the cold water.

Figure 3: Work sample (Ely)



Practical Number 23.

aim: To find out what environment will break down the rock faster. Hot rock in cold water or hot rock in warm water.

Method: ①. measure the mass of the rock.
②. Heat the granite rock and put in cool water
③ Measure the mass of the rock after you put the water throug the filter funnel.
④ Redo with worm water.

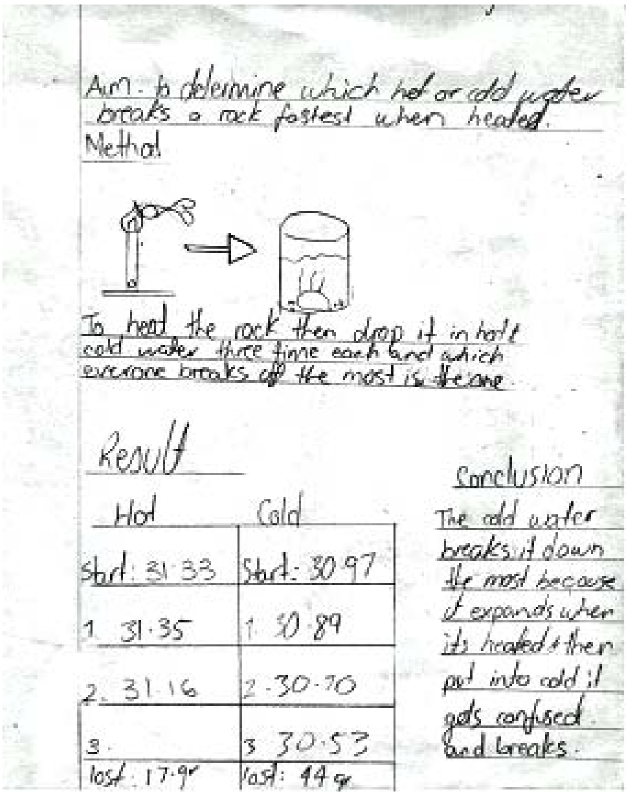
Result:

warm water		cold water	
61.47	60.95	60.29	51.06
before	after	before	after

conclusion: The cold water works better becouse the rock expands and then contracts quickly and has no choice but to break up

Hypothesis: I thought that the hot rock and cold water would work better because it works with glass aswell becouse it expands and then quickly contracts

Figure 4: Work sample (Danny)



Aim: to determine which hot or cold water breaks a rock fastest when heated.

Method

To heat the rock then drop it in hot / cold water three time each and which everyone breaks off the most is the one

Result

Hot	Cold
Start: 31·33	Start: 30·97
1 31·35	1 30·89
2 31·16	2 30·70
3	3 30·53
lost: 17·9g	lost: 44 g

Conclusion

The cold water breaks it down the most because it expands when its heated + then put into cold it gets confused and breaks.

Figure 5: *Melissa's work sample*

The analysis of the assessment was based on the three principles of scientific literacy: All three work samples were personal representations based on each student's own developing understandings of science. The assessment developed around the *process* of science and was represented by all three students as a conventionally written sequence of the methodology; the data (measurements) tabulated as results and in one case *(figure 5)* the idea of replicating the measurements. Ely (Figure 3) had established more of a vocabulary of factual words including, abiotic, weathering and environment used in the context of the activity and beyond. From these results students identified the *concept* of a change in temperature led first to expansion followed by contraction of the rock which resulted in the breakdown of rock into fragments. However, two students interpreted the concept from a less scientific view although there was some evidence of the transferability of learning, both students displaced scientific explanations with narrative-like discourse *(*Figures 4 and 5*)* in this case animistic representations (Klein, 2006).

> "The cold water breaks it down the most because it expands when it is heated and then put into cold it gets *confused* and breaks.*(figure 5).*

> "The cold water works better because the rock expands and then contracts quickly and has no choice but to break up." *(figure 4).*

In a focus group interview Boyd related a more pragmatic reaction toward the activity, responding to the teacher's question by acknowledging the laboratory is not the "real world":

> T- Did you learn anything today about science?
>
> Boyd - That sand and rocks are the same ...large rocks break down to sand with a sudden change in heat.
>
> T- Could you relate that to real life?
>
> Boyd -Yes except rocks won't crack like that (Boyd, Interview, 23/06/05)

Student focus groups interviews confirmed an initial enthusiasm for these science activities.

> Fun fun, fun because you get to do lot of pracs better than primary I didn't think it would be better. (Matt, interview, 26/05/05)

The revised CLES (Dryden & Fraser, 1998) was administered to the year seven class (N=29) as both a pre-test post-test. However the teacher had the class 10 weeks prior to the study. Scores on CLES scales were converted to a scale 0 to 100 by scoring 0 for almost never, 25 for seldom, 50 for sometimes, 75 for often and 100 for almost always. The results are shown in Table 4.

Table 4: *Learning environment survey results*

CLES Scale	Test	Mean	SD	t
Personal	Pre-	53.59	26.30	
Relevance	Post-	59.78	25.33	2.17
Critical	Pre-	63.00	34.31	
Voice	Post-	74.69	28.82	3.35
Uncertainty	Pre-	55.03	30.05	
Of Science	Post-	60.03	27.93	1.58
Shared	Pre-	31.07	28.90	
Control	Post-	29.78	29.82	0.40
Student	Pre-	73.84	27.20	
Negotiation	Post-	77.07	26.90	1.09

0=Almost Never, 25= Seldom, 50= Sometimes, 75= Often, 100= Almost Always

Results within the class (pre-test, post-test) were indicative of a classroom environment that whilst teacher-centred (shared control, mean 29.78, seldom experienced) had developed a social climate more attuned to the middle school paradigm. Students were able to express concerns about any impediments to their learning, critical voice mean, 74.69 (often experienced) and there was an indication that pedagogical strategies helped promote opportunities for students to discuss their newly developing ideas with their peers in an effort to reflect self-critically on their own understandings student negotiation, mean 77.07 (often experienced). Both critical voice and student negotiation are considered meta-cognitive strategies, students being able to question first what they were doing, ascertain how they were doing it and why.

DISCUSSION

Adolescent students are torn between a quest for personal identity and at the same time belonging and being accepted by the group. The provision for and encouragement of student autonomy within the study class group helped establish a classroom psychological environment that took into account student belonging. Students were supported to resolve the ambiguity of the teacher explanation through negotiation and critical voice, which encouraged a behavioural engagement that led toward cognitive engagement (Eccles & Midgley, 1998; Pintrich, 2003; Ryan & Patrick, 2001; Wentzel, 2003; Fredrickson, 2001; Fredricks, Blumenfield & Paris, 2004). This enhanced engagement was evidenced by the video transcriptions of classroom interaction and corroborated by the teaching journal and focus group interview transcripts. This student autonomy encouraged meta-cognitive strategies including questioning and discussion of content in context with both the teacher and their peers. Cognitive growth was evidenced as new learning within work samples where students' had to think about their learning as they re-worked scientific ideas collaboratively from past experience.

The intervention took on an approach that encouraged the students to slowly work scientific ideas into their personal narratives. Learning was not seen as sequential way of conceptual understanding (Tytler, 2007), nor a quantitative evolution of thinking but as a dynamic qualitative type (Vygotsky, 1986). Meta-cognitive strategies helped student thinking to become "more visible" supported by classroom talk, both pupil-pupil talk, teacher-pupil talk (McGuinness, 2005).

Toward being more effective teachers of adolescents it is important to realise that we need to meet the students' social and emotional needs otherwise the teachers content-area expertise could be wasted (Daniels, 2005; San Antonio, 2006; Jablon & Van Sickle, 2003). The presentation of content itself is not a real problem, what is important is to make that content meaningful to the students (Tytler, 2007). In this study the content was treated in *depth* as a way of trying to make the concepts presented more meaningful through pedagogical strategies that incorporated the following considerations:

- Collaborative practical activities that gave time for the teacher and students to start to establish an environment where students could build upon their scientific understandings and affirm that science could be fun. These extended activities also allow time for the teacher to conduct a broad situational analysis by observation, listening and discussion with the students (Black & Wiliam, 1998) as a means of assessment of student scientific understanding and confirming some form of positive social relationships were evolving within the class grouping.

- A model influenced by the cognitive apprenticeship approach (Collins, Brown & Newman, 1989), whereby the teacher initially explicitly modelled the activity followed by a scaffold that allowed for more student autonomy (Brown, Collins & Duguid, 1989; Schuh, 2004; Lave & Wenger, 1991; Vygotsky, 1931). The teacher manipulating the learning situation, by encouraging students through the scientific *process* to enrich their understandings by re-working scientific ideas in different contexts, then explicitly involving students in a reflective process toward consolidation of scientific understanding (Klein, 2006; White & Frederiksen, 1998).

CONCLUSIONS

Content and *process* were seen in this study as interdependent. Scientific *process* was embedded in the activities as a mechanism toward understand the *content*. *Processes* included collaborative research, experimental techniques, observation (classification), measurement, the use of tables, and diagrams were all representational and contributed toward model development. From the evidence above student understanding of, and explanation of scientific ideas is a process of slow and individual evolution. The intervention in retrospect had developed as a narrative with a pragmatic approach to learning; the teacher endeavoured to present the students with a more holistic view of scientific thinking within a complex living system (Schuh, 2004). Where possible the teacher blended themes discursively, attempting to develop in adolescents a core scientific literacy (Hill & Russell, 1999; Tytler, 2007). Student observation of activities had led toward scientific understanding based on student negotiated perceptions of their shared practical experiences of science.

From the teaching perspective this was a deeply satisfying method of engaging students in the content of the curriculum. Students came to class enthusiastically with expectations of learning through activities that were more contextually relevant to their learning. Both teacher and student participation was stimulated by fostering meta-cognitive practices that encouraged new learning through open dialogue, multi-modal representations and assessments that contributed to building upon, re-affirming, or challenging both the student's prior learning and the teacher's pedagogical content knowledge.

From a personal perspective of a teacher/researcher, I (author 1) have come closer to appreciating how adolescent students react to their world. I have enjoyed the dynamism of a classroom where you realise if there is a feeling of inclusiveness, students' rise to challenges as they demonstrate a "wish to know."

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